The Veterinary Journal 197 (2013) 311–317

Contents lists available at SciVerse ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Quantitative estimation of the impact of caprine arthritis encephalitis virus infection on milk production by dairy goats

Bernardo Martínez-Navalón [a], Cristòfol Peris [b], Ernesto A. Gómez [c], Bernat Peris [d], María Luz Roche [d], Concepción Caballero [d], Elena Goyena [e], Eduardo Berriatua [e,*]

[a] Centro de Salud Pública de Manises, Conselleria de Sanidad, C/Ceramista Alfons Blat 6, 46600 Manises, Valencia, Spain
[b] Institut de Ciència i Tecnologia Animal, Universidad Politécnica de Valencia, 46071 Valencia, Spain
[c] CITA-IVIA, Instituto Valenciano de Investigaciones Agrarias, Apartado 187, 12400 Segorbe, Castellón, Spain
[d] Unidad de Análisis de Sanidad Animal, Conselleria de Agricultura, Pesca, Alimentación y Agua, 46024 Valencia, Spain
[e] Sanidad Animal, Facultad de Veterinaria, Universidad de Murcia, Campus de Espinardo, 30100 Murcia, Spain

ARTICLE INFO

Article history:
Accepted 21 December 2012

Keywords:
Goat
Dairy
Caprine arthritis encephalitis virus (CAEV)
Seroprevalence
Milk production

ABSTRACT

This retrospective study investigated milk production losses associated with serological evidence (serostatus) of caprine arthritis encephalitis virus (CAEV) infection over one lactation in 4543 Murciano-Granadina goats from 22 herds in Spain. The seroprevalence of infection was 18%, ranging from 0% to 2% in 11 herds, 7% to 60% in 10 herds and was 100% in one herd. Seropositive does had significantly shorter lactations, produced less milk and milk fat, lactose and dry extract and had higher somatic cell counts than their seronegative counterparts, although differences in milk production between seropositive and seronegative animals were noted between herds.

Mixed regression models confirmed the association between CAEV seropositivity and reduced milk production. The adjusted, least squares mean (LSM) test-day milk yield was 10% less in seropositive compared to seronegative does and this difference varied according to lactation number. In contrast, differences in the LSM of milk fat, lactose and dry extract percentages between seropositive and seronegative goats were only between 0.1% and 0.2% and did not increase with lactation number. The findings of this study provide strong evidence that CAEV-infection can be a major cause of reduction in milk yield in goats and its control should be considered as part of dairy goat herd health schemes.
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Introduction

Caprine arthritis encephalitis virus (CAEV) and maedi–visna virus (MVV) are small ruminant lentiviruses (SRLVs) with a tropism for the monocyte–macrophage cell lineage of sheep and goats. Infection stimulates a chronic, intense, inflammatory response affecting the brain, lungs, joints and mammary gland which is ineffective in eliminating the virus (Narayan and Cork, 1985). These lentiviruses replicate slowly and animals may be latently infected for many years before developing clinical signs. Infection may occur after birth with the ingestion of virus-contaminated colostrum and milk, and throughout life by exposure to the lung secretions of infected animals (Blacklaws et al., 2004). Most infected animals develop specific circulating antibodies shortly following infection, which are detectable using recombinant ELISAs (de Andrés et al., 2005).

Evaluating production losses due to SRLV infections is complex as this is influenced by virus strain, host and management factors that may differ widely between studies (Peterhans et al., 2004). The negative impact of these infections is greatest in immunologically naïve and intensively raised stock (Blacklaws et al., 2004; Benavides et al., 2006; Leginagoikoa et al., 2006a,b). Quantitative data relating to the financial impact of SRLV infection are limited. Peterhans et al. (2004) estimated milk production losses to be approximately 10%.

Seropositivity to CAEV is associated with reduced lactation length, milk fat and protein yield, as well with an increased incidence of other diseases and reduced birth-weight (Smith and Cutlip, 1988; Greenwood et al., 1995). In contrast, Leitner et al. (2010) reported similar milk yields in CAEV seropositive and seronegative does in their second or further lactations and found that milk yield was greater in seronegative, first lactation animals. Other studies examining primiparous goats found no relationship between CAEV seropositivity and milk production (Nord and Adnøy, 1997; Turin et al., 2005). Such conflicting results highlight the need to further clarify the impact of CAEV infection in dairy goats (Peterhans et al., 2004).

The Murciano-Granadina (MG) goat breed originates from Spain and has been selected and used in milk production in many coun-

* Corresponding author. Tel.: +34 868 883 997.
E-mail address: berriatu@um.es (E. Berriatua).

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http://dx.doi.org/10.1016/j.tvjl.2012.12.020

tries (Gonzalo et al., 2002). Given that CAEV infection occurs in this breed (Contreras et al., 1998), we established a study to assess its impact on milk production in selected MG herds.

Materials and methods

Herd selection

This retrospective study used total lactation and test-day milk production data from one lactation of 4543/5073 (90%) MG does from all 22 herds belonging to the Asociación de Ganaderos de Caprino de Raza Murciano-Granadina de la Comunidad Valenciana. The goats had given birth between September 2005 and January 2008, and 530 animals were excluded that were either seropositive >6 months after, or seronegative ⩽6 months before, kidding. This was to minimise the misclassification of animals by eliminating those of uncertain serostatus during the lactation, namely, seropositive animals that may have been seronegative during the first 6 months of lactation, and seronegative animals that may have seroconverted during gestation/lactation.

All study herds were kept permanently indoors and the number of lactating does ranged 44–695 does/herd (median [interquartile range], 167 [120–279] does/herd). The pre-weaning rearing of kids differed between herd: in five herds kids where kept with their dams until 5–6 weeks old; in 11 herds kids were permanently separated from their dams and fed milk substitutes, and in six herds both of the above management systems were practiced. Goats were milked once daily on all study farms. Additional data collected from farms included birth dates, life-long kidding dates and numbers of kids born/numbers of abortions.

Sampling and analysis of milk

In line with the regulations of the Spanish Ministry of Agriculture[1], herds were visited every 42 ± 3 days, when milk samples were collected. Daily milk yield, fat, protein, dry extract and lactose content, and somatic cell counts (SCCs) were recorded. Milk yields monitored with Tru-test meters were used to calculate the total milk yield (MY_T) using the formula:

$$MY_T = (TD_1 - KD) * MY_1 + (TD_2 - TD_1) * ((MY_2 + MY_1)/2) + (TD_3 - TD_2) * ((MY_3 + MY_2)/2) + \cdots + (TD_n - TD_{n-1}) * ((MY_n + MY_{n-1})/2) + MY_n * 21$$

where $TD_{1\ldots n}$ are the test dates $1 - n$, KD are the kidding dates, and $MY_{1\ldots n}$ is the milk yield on test dates $1 - n$.

Milk samples conserved in azidiol were used to obtain the percentage of milk constituents and the SCC using automated MilkoScan FT6000 and Fosssomatic FC (Foss Electric) milk analysers, respectively. Milk fat, protein, dry extract and lactose percentages were standardised calculating normalised percentages (NP), for production over the first 150 and 210 days of lactation for the first, and second or greater lactation does, respectively, using the formula:

$$NP_{MC,150/210} = 100 * \frac{KG_{MC,150/210}}{MY_{150/210}}$$

where $NP_{MC,150/210}$ is the normalised percentage for a milk component and lactation group, $KG_{MC,150/210}$ the amount (kg) of milk component and lactation group, and $MY_{150/210}$ the milk yield (L) according to lactation group. Similarly, the geometric mean of test-day analysis in the first 150 and 210 days of lactation was used as a normalised SCC value for first and second or greater lactation does, respectively.

Serology

Serum was tested using an indirect ELISA (Pourquier Maedi–Visna/CAEV version P00303), following the manufacturer's instructions. Animals were classified as seronegative, seropositive or inconclusive at M/P percentages of ⩽110, ⩾120, and 111–119, respectively, using the formula:

$$M/P = \frac{ODS_{450} - ODNcon_{450}}{ODPcon_{450} - ODNcon_{450}}$$

where ODS_{450} is the optical density (OD) of the sample at 450 nm, $ODNcon_{450}$ the OD of the negative control (450 nm), and $ODPcon_{450}$ the mean OD of the positive controls (450 nm).

Test validity data had been established by the manufacturers in a study in Lacaune sheep. The estimated minimum specificity was >99.8%. Sensitivity was assessed relative to an agar immunodiffusion test (AGID): since seroprevalences using the AGID and ELISA were 18% and 21%, respectively, the latter test was considered to be more sensitive. The sensitivity of the AGID for CAEV antibodies relative to reference radio-immuno-precipitation was 91% (de Andrés et al., 2005).

Statistical analysis

Analysis in Epi Info 2007[2] included ANOVA for means of explanatory variables including lactation number (parity) and stage, parity season, offspring number, total milk yield, normalised milk protein, fat, lactose and dry extract content, and SCC, for both seropositive and seronegative goats. Mixed linear regression models were developed using PROCMIXED in SAS (SAS Institute) to further investigate the relationship between the antibody status and test-day milk yield, adjusting for explanatory variables. Goats suckling kids were excluded from this analysis. Dependent continuous variables in separate models were test-day milk yield, as well as milk fat, protein, dry extract and lactose percentages.

Fixed explanatory variables were parity season (Spring, Summer, Autumn, Winter), offspring number (1, 2, ⩾3, or aborted), lactation month (1–9 months), lactation duration (three levels according to terciles) and number (1, 2, 3, 4, 5, ⩾6), herd CAEV seroprevalence (three levels according to its trimodal distribution: 0–9% for 13 herds and 2485 goats; 19–35% for six herds and 1541 goats; and 52–100% for three herds and 477 goats) and serostatus (seropositive or seronegative). 'Herd' was modelled as a random effect assuming a diagonal covariance matrix. Models considered the correlation between repeated test-day results in the same goat as having a compound-symmetry (CS), as autoregressive with a lag of 1 (AR-1) structure, or as unstructured (UN) (Singer, 1998; Gröhn et al., 1999).

A backward-elimination model building strategy was used starting with all explanatory variables and the interaction between serostatus and parity number (Kleinbaum et al., 1998). Final models included variables significantly associated with the outcome and Akaike's information criterion (AIC) was used to compare the 'goodness-of-fit' of models (Singer, 1998). Parameters were estimated using the 'least-square' method and partial *F*-tests were used for significance with alpha taken at the 5% ($P < 0.05$) level for a two-tailed test.

Results

Animal and herd seroprevalence

The percentage of seropositive, seronegative and inconclusive ELISA results were 17.8% (807/4543), 82.0% (3726/4543) and 0.2% (10/4543), respectively. Excluding inconclusive results, the seroprevalence was 18% (807/4533): 0% in five herds (0/620 animals); 1–2% in six herds (12/997 animals); 7–9% in two herds (76/898 animals); 19–35% in six herds (436/1541 animals), and 52% (68/131 animals), 60% (200/331 animals), and 100% (15/15 animals) in three herds ($P < 0.05$), respectively. In herds with a seroprevalence between 7% and 100%, the age-specific seroprevalence was 19% in 1 year olds, 15% among 2 year olds and increased to 39–42% among ⩾6 year olds ($P < 0.05$), respectively.

Lactation length and milk production parameters

Table 1 details the arithmetic means of lactation duration, total milk yield, normalised milk fat, protein, dry extract and lactose percentages, and the geometric mean of the normalised SCC in 3913 seronegative and seropositive goats (excluding goats missing values in these variables), respectively. Seronegative does had longer lactations (218 vs. 204 days), higher mean milk yields (446 vs. 374 L) and higher fat, dry extract and lactose NPs, compared to seropositive does. Seropositive does had higher normalised mean SCCs ($P < 0.05$) (Table 1). However, differences in milk production varied with animal serological status in the 10 herds with a seroprevalence between 7% and 60%: the mean lactation milk yield was similar in seropositive and seronegative does in seven herds, and was lower in seropositive compared to seronegative does in three herds (Table 2).

Overall differences in milk production varied according to lactation (parity) number and duration (Table 1). Milk yield was greater for seronegative, greater than third lactation does compared to seropositive animals of the same lactation ($P < 0.05$), was marginally greater for second lactation seronegative does ($P = 0.09$), and was similar for first lactation seronegative and seropositive does.

Differences between seronegative and seropositive animals in the NP milk components were small and did not exhibit a consis-

[1] Real Decreto 368/2005, Boletín Oficial del Estado, 23/04/2005.

[2] See: http://wwwn.cdc.gov/epiinfo/.

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